

What is claimed is:

1. An NROM memory transistor comprising:
a substrate having a plurality of source/drain regions, the source/drain regions having a different conductivity type than the remainder of the substrate;
a nanolaminate, high permittivity (high-k), metal gate dielectric formed by an oxidation of metal overlying the substrate, the gate dielectric having a dielectric constant greater than a dielectric constant of silicon dioxide; and
a control gate formed on top of the gate dielectric.
2. The transistor of claim 1 wherein the gate dielectric is a composite oxide – high-k dielectric – oxide nanolaminate gate insulator wherein the high-k dielectric is a charge trapping layer formed by low temperature oxidation of metal.
3. The transistor of claim 1 wherein the gate dielectric is a composite oxide – oxide – high-k dielectric nanolaminate gate insulator wherein the nitride layer is a charge trapping layer formed by low temperature oxidation of metal.
4. The transistor of claim 1 wherein the transistor is used in either a NOR-type flash memory structure or a NAND-type flash memory structure.
5. The transistor of claim 2 wherein the charge trapping layer is comprised of a material that has a lower conduction band edge than silicon nitride.
6. The transistor of claim 2 wherein the gate dielectric has a larger energy barrier between the high-k dielectric and the oxide insulator than silicon dioxide.
7. The transistor of claim 1 wherein the gate dielectric is comprised of one of the following structures: oxide – oxidized Hf – oxide, oxide – oxidized Zr – oxide, or oxide – oxidized Al – oxide.

8. An NROM memory transistor comprising:
a substrate having a plurality of source/drain regions, the source/drain regions
having a different conductivity than the remainder of the substrate;
a composite gate insulator layer formed by oxidation of metals overlying the
substrate and substantially between the plurality of source/drain regions, the
gate insulator comprising a trapping layer having a higher dielectric
constant than silicon dioxide; and
a control gate formed on top of the gate insulator layer.
9. The transistor of claim 8 wherein the composite gate insulator comprises an oxide –
oxide – high-k dielectric structure.
10. The transistor of claim 8 wherein the composite gate insulator comprises a
perovskite oxide film.
11. The transistor of claim 8 wherein the composite gate insulator comprises a stack of
oxide films having properties of high dielectric constant (k) oxide – low-k oxide –
high-k oxide.
12. The transistor of claim 8 wherein the composite gate insulator is formed by low
temperature oxidation.
13. The transistor of claim 8 wherein the plurality of source/drain regions are
comprised of an n+ type doped silicon.
14. The transistor of claim 8 wherein the control gate is a polysilicon material.
15. The transistor of claim 8 wherein the substrate is comprised of a p+ type silicon
material.

16. The transistor of claim 8 wherein the composite gate insulator layer is comprised of one of the following structures: oxide – oxide – Al_2O_3 , oxide – oxide – HfO_2 , or oxide – oxide – ZrO_2 wherein the metal oxide layers are formed by low temperature oxidation.
17. An NROM memory transistor comprising:
a substrate having a plurality of source/drain regions, the source/drain regions
having a different conductivity than the remainder of the substrate;
a nanolaminate, high permittivity, oxidized metal gate insulator layer formed by
low temperature oxidation overlying the substrate; the gate insulator
comprising a structure having a plurality of layers each having a dielectric
constant that is higher than silicon dioxide; and
a control gate formed on top of the gate insulator layer.
18. The transistor of claim 17 wherein the substrate is comprised of a p+ type
conductivity silicon and the source/drain regions are n+ doped regions in the
substrate and the gate insulator is formed substantially between the source/drain
regions.
19. An NROM memory transistor comprising:
a substrate having a plurality of source/drain regions, the source/drain regions
having a different conductivity than the remainder of the substrate;
a nanolaminate, high permittivity, oxidized metal gate insulator layer formed by
low temperature oxidation overlying the substrate, the gate insulator
comprising a structure having a plurality of layers each having a different
dielectric constant properties; and
a control gate formed on top of the gate insulator layer.
20. An electronic system comprising:

a processor that generates control signals; and
a memory array coupled to the processor, the array comprising a plurality of
NROM memory cells, each NROM memory cell comprising:
a substrate having a plurality of source/drain regions, the source/drain
regions having a different conductivity type than the remainder of
the substrate;
a nanolaminate, high permittivity (high-k), metal gate dielectric formed by
an oxidation of metal overlying the substrate, the gate dielectric
having a dielectric constant greater than a dielectric constant of
silicon dioxide; and
a control gate formed on top of the gate dielectric.

21. A method for fabricating an NROM memory cell, the method comprising:
creating a plurality of source/drain regions by doping portions of a substrate;
forming a nanolaminate gate insulator on the substrate, the gate insulator having a
dielectric constant that is higher than silicon dioxide;
low temperature oxidizing at least one metal layer of the nanolaminate gate
insulator; and
forming a control gate on the oxide insulator material.
22. The method of claim 21 wherein the plurality of source/drain regions are created
with a p+ conductivity in an n+ substrate.
23. The method of claim 21 wherein the gate insulator is comprised of an oxide – high-
k dielectric – oxide structure.
24. The method of claim 21 wherein the gate insulator is comprised of an oxide – oxide
– high-k dielectric structure.

25. The method of claim 21 wherein the gate insulator is comprised of a high-k dielectric – high-k dielectric – high-k dielectric structure.
26. The method of claim 21 wherein forming the gate insulator comprises forming one of the following structures: oxide – HfO₂ – oxide, oxide – ZrO₂ – oxide, or oxide – Al₂O₃ – oxide.
27. The method of claim 21 wherein forming the gate insulator comprises forming one of the following structures: oxide – oxide – Al₂O₃, oxide – oxide – HfO₂, or oxide – oxide – ZrO₂
28. The method of claim 21 wherein forming the gate insulator comprises an atomic layer deposition technique prior to the low temperature metal oxidation.
29. The method of claim 21 wherein forming the gate insulator comprises an evaporation technique prior to the low temperature metal oxidation.
30. The method of claim 21 wherein forming the gate insulator comprises an atomic layer deposition technique and an evaporation technique prior to the low temperature metal oxidation.
31. A method for fabricating an NROM memory cell, the method comprising:
creating a plurality of source/drain regions by doping portions of a substrate;
forming a tunnel oxide layer on the substrate;
forming a gate dielectric layer with a low temperature metal oxidation technique on the tunnel oxide layer, the gate dielectric layer having a dielectric constant that is higher than silicon dioxide;
forming an oxide layer on the gate dielectric layer; and
forming a control gate on the oxide insulator material.

32. The method of claim 31 wherein forming the gate dielectric layer further comprises evaporating one of the following materials: HfO_2 , ZrO_2 , LaAlO_3 , Y_2O_3 , Gd_2O_3 , TiO_2 , CrTiO_3 , or YSiO_3 .
33. A method for fabricating an NROM memory cell, the method comprising:
creating a plurality of source/drain regions by doping portions of a substrate;
forming a tunnel oxide layer on the substrate;
forming a gate dielectric layer using a low temperature metal oxidation on the tunnel oxide layer, the gate dielectric layer having a dielectric constant that is higher than silicon dioxide;
forming an oxide layer on the gate dielectric layer; and
forming a control gate on the oxide insulator material.
34. The method of claim 33 wherein the gate dielectric layer comprises atomic layer deposition of one of the following materials: HfO_2 , ZrO_2 , Al_2O_3 , La_2O_3 , LaAlO_3 , HfAlO_3 , Ta_2O_5 , TiO_2 , or Pr_2O_3 .
35. A method for fabricating an NROM memory cell, the method comprising:
creating a plurality of source/drain regions by doping portions of a substrate;
forming a tunnel oxide layer on the substrate;
forming a nitride layer on the tunnel oxide layer; and
forming a gate dielectric layer with a low temperature metal oxidation technique on the nitride layer, the gate dielectric layer having a dielectric constant that is higher than silicon dioxide;
forming a control gate on the oxide insulator material.
36. The method of claim 35 wherein forming the gate dielectric layer comprises deposition of one of the following materials: Al_2O_3 , HfO_2 , or ZrO_2 wherein the metal is oxidized by low temperature oxidation.

37. A method for fabricating an NROM memory cell, the method comprising:
creating a plurality of source/drain regions by doping portions of a substrate;
forming a nanolaminate gate dielectric layer with a low temperature metal
oxidation technique on the substrate, the gate dielectric layer having a
dielectric constant that is higher than silicon dioxide; and
forming a control gate on the oxide insulator material.
48. The method of claim 39 wherein the gate dielectric layer is formed on the substrate
substantially between the source/drain regions.